ALPINE FLORA OF THE SWEETWATER MOUNTAINS, MONO COUNTY, CALIFORNIA

KATHERINE BELL HUNTER
Department of Biological Sciences, University of Nevada,
Las Vegas 89154

RICHARD E. JOHNSON
Department of Zoology and Marion Ownbey Herbarium,
Washington State University, Pullman 99164

ABSTRACT

The Sweetwater Mountains of Mono County, California, lie along the transition between Sierra Nevada and Great Basin floras. The alpine zone of the range, defined as the area above that dominated by shrubby *Artemisia* species of the section Tridentae, is 16 km^2. The zone includes persistent snowdrifts and streams, some frost-sorted soils, and four rock substrates: rhyolite, andesite, granite, and quartz monzonite. The alpine flora includes 173 species of vascular plants. Many taxa show considerable preference for a single substrate. Ninety-four percent of the Sweetwater alpine taxa are also found in the Sierra Nevada, 75% in the Great Basin, 52% in the southern Rocky Mountains, and 18% in the Arctic.

A comparison of alpine floristics of four ranges along the western perimenter of the Great Basin (the Sweetwater, Wassuk, White, and Spring Mountains) indicates that the Sweetwater and Wassuk alpine zones are relatively less isolated than the other islands. The unusually large flora of the Sweetwaters may be related to the range's accessibility to both Great Basin and Sierra Nevada floras and to the presence of appropriate microsites for both Great Basin xerophytes and Sierran mesophytes.

INTRODUCTION

A series of three mountain ranges in western Nevada and eastern California contain the westernmost alpine areas of the Great Basin. The floras of the southern two, the Spring Mountains (Clark County, Nevada) and the White Mountains (Mono County, California, and Esmeralda County, Nevada), have been described in detail by Clokey (1951) and Lloyd and Mitchell (1973), respectively. The alpine flora of the third, the Sweetwater Mountains (Mono County, California), has been only partially documented (Major and Taylor 1977). Although these ranges all lie along the western perimeter of the Great Basin, they form alpine islands with considerably different degrees of isolation.

The Spring Mountains are the most remote from other alpine areas because three desert ranges and four deep valleys separate them from the Sierra Nevada to the west. The nearest alpine area to the east lies on the Markagunt Plateau (Iron County, Utah), 190 km distant. Clokey (1951) found the Spring Mountain flora to have been derived from

MADROÑO, Vol. 30, No. 4, pp. 89–105, 10 November Supplement 1983

both the flora of the Sierra Nevada and that of southwestern Utah. The range has an exceptionally high degree of endemism, which Clokey attributed to a long period of isolation.

The White Mountains, separated from the Sierra Nevada by Owens Valley, have a much more Sierran flora than the Spring Mountains (Lloyd and Mitchell 1973). Their lower degree of isolation is also reflected in a smaller endemic flora despite a much larger area at high elevations.

The Sweetwater Mountains lie only 33 km east of the crest of the Sierra Nevada with a possible route for overland plant migration across Devil's Gate at 2281 m elevation. Immediately to the east of the Sweetwaters, the Wassuk Range (Mineral County, Nevada) contains a strong Sierran element in its alpine flora (Bell and Johnson 1980), suggesting that both ranges may be readily accessible to Sierran taxa. The Sweetwaters might, therefore, be expected to have an alpine flora heavily influenced by the Sierra Nevada, but the partial species list by Major and Taylor (1977) indicates that widespread Cordilleran and Great Basin species both outnumber Sierran taxa in the Sweetwaters. This report presents a more complete species list for the alpine zone of the Sweetwater Mountains, allowing for a more precise comparison of alpine floristics along the western perimeter of the Great Basin.

The Alpine Zone of the Sweetwater Mountains

The geology of the Sweetwater Mountains is complex and incompletely described. Surface rocks in the alpine zone are primarily Miocene rhyolite and andesite with small outcrops of Cretaceous quartz monzonite and granite (Slemmons 1966; G. F. Brem, pers. comm.). Much of the rhyolite has been silicified, and some of the andesite has undergone intense hydrothermal alteration (G. F. Brem, pers. comm.).

The alpine zone lies on a rolling upland cut by a number of deep canyons. The canyon sides are primarily unstable talus; there are few cliffs.

Soils are, for the most part, poorly developed with no organic horizons and little evidence of leaching. Exceptions are found, however, in boggy sedge meadows along a few drainages. Many of the flat upland surfaces are covered by sorted polygons, and some slopes have sorted rock stripes. Andesite-derived soils have a high clay content in many areas, and these fine-textured soils are heavily worked by pocket gophers.

The climate of the Sweetwater Mountains is, to our knowledge, undescribed. The range has a number of snowbanks that persist through the summer even in years of regional drought. Springs and seeps also furnish water in summer, despite long periods without summer rainfall. Thus, the Sweetwaters have the appearance of being more mesic than most Great Basin ranges.

The high elevation vegetation in the Sweetwaters has been partially described by Major and Taylor (1977). In a few places, scattered white-bark pines form a boundary for the alpine zone. Throughout much the range, woody *Artemisia* species of the section Tridentae are replaced at higher elevations by low shrub communities, generally dominated by *Chrysothamnus* spp., above which are barren slopes with scattered grasses and cushion plants. Seeps and protected flats support a more dense meadow vegetation; and lush sedge meadows occur along a few streams, especially Frying Pan Creek and its tributaries. In an earlier study (Bell and Johnson 1980) we suggested that the upper edge of the shrubby *Artemisia* community forms the equivalent of treeline where trees are absent in Great Basin ranges. This definition appears applicable to the Sweetwater Mountains, and plants included in this species list were all found above that boundary.

Collections were made in the Sweetwater Mountains during the summers 1976–1979 and 1982. Nomenclature follows Kartesz and Kartesz (1980). Voucher specimens are deposited in UNLV and WS. Geographical distributions are based on the following: Sierra Nevada (SN): Munz (1973), Sharsmith (1940), Taylor (1976a); White Mountains: Lloyd and Mitchell (1973); Great Basin (GB): Cronquist et al. (1972, 1977), Hansen (1956), Hunter and Johnson (unpublished data), Lewis (1971, 1973, 1975), Linsdale et al. (1952), Loope (1969), McMillan (1948), Preece (1950); southern Rocky Mountains (Ro): Harrington (1964), Weber (1976); Arctic (Ar): Polunin (1959).

Alpine Plants of the Sweetwater Range

Lycophyta

Selaginellaceae

Selaginella watsonii. Uncommon; among rocks in snow accumulation areas on rhyolite. SN, GB.

Pterophyta

Aspidiceae

Cystopteris fragilis. Uncommon; among rocks on north-facing slopes, under winter snow; not found on andesite. SN, GB, Ro, Ar.

Woodsia oregana. Rare; from a single rocky granite slope south of Wheeler Peak. SN, GB, Ro.

Anthophyta—Monocotyledoneae

Cyperaceae

Carex brevipes. Locally common in small areas of dry, generally gravelly, soil; on rhyolite and granite. SN, GB, Ro.

Carex douglasii. Rare; in dry gravel flats on rhyolite. SN, GB, Ro.
Carex foetida. Very rare; in a single wet sedge meadow south of Wheeler Peak; in organic soil. SN, Ro.
Carex haydeniana. Rare; at seeps on talus slopes. SN, GB, Ro.
Carex helleri. Common; generally in deep snow accumulation areas, less common at persistent seeps on talus slopes; on various rock types. SN, GB.
Carex heteroneura var. *brevisquama*. Locally common; in moist snow accumulation areas; primarily on rhyolite. SN, GB, Ro, Ar.
Carex jonesii. Very rare; in moist gravel on the northeast slope of Wheeler Peak. SN, GB, Ro.
Carex leporinella. Extremely rare; in organic soil in a single wet meadow south of Wheeler Peak. SN.
Carex microptera. Uncommon; in wet, rocky soil of deep snow accumulation areas; generally on rhyolite. SN, GB, Ro.
Carex phaeocephala. Common; in snow accumulation areas; most common on rhyolite but also found on dacite, andesite and granite. SN, GB, Ro.
Carex scopulorum. Rare; in wet meadows below persistent snowbanks; on rhyolite. SN, GB, Ro.
Carex straminiformis. Rare; in deep gullies, generally on rocky slopes under winter snow but melting in early summer. SN.
Carex subnigricans. Dominant in flat or nearly flat meadows that remain wet and cold throughout the summer; forming deep turf. SN, GB.

Juncaceae

Juncus balticus var. *montanus*. Locally abundant, but restricted to a single slope of weathered andesite on the ridge between South Sister and the southern portion of the range. SN, GB, Ro, Ar.
Juncus orthophyllus. Rare; known from a single wet sedge meadow along Frying Pan Creek; in organic soil. SN, GB.
Juncus parryi. Moderately common; moist to dry gravel slopes; generally on rhyolite. SN, GB, Ro.
Luzula multiflora subsp. *comosa*. Uncommon; in organic soils of wet sedge meadows. SN, GB, Ro, Ar.
Luzula spicata. Uncommon; in areas of shallow snow accumulation on gravel soils of various rock types. SN, GB, Ro, Ar.

Poaceae

Agropyron pringlei. Uncommon; in loose scree; on rhyolite and dacite. SN.
Agrostis variabilis. Uncommon; very wet meadows; in organic soil. SN, GB, Ro.
Alopecurus geniculatus. Very rare; in a single persisting, shallow pool below a melting snowbank; on andesite. SN, Ro, Ar.

Calamagrostis purpurascens. Uncommon; on rocky, but stable, slopes; on all rock types. SN, GB, Ro, Ar.

Deschampsia caespitosa. Locally dominant; in wet meadows; in organic soil. SN, GB, Ro, Ar.

Elymus cinereus. Rare; on rocky, stable slopes; on grante. GB, Ro.

Festuca brachyphylla. Abundant; generally present except in deep snow accumulation areas; on rock types but more common on rhyolite. SN, GB, Ro, Ar.

Hordeum brachyantherum. Very rare; at a single site in upper Ferris Creek Canyon. SN, GB, Ro.

Koeleria cristata. Rare; on south-facing slopes; absent on andesite. SN, GB, Ro.

Leucopoa kingii. Uncommon; on stable rocky slopes in snow accumulation areas; on rhyolite. SN, GB, Ro.

Muhlenbergia richardsonis. Locally dominant in small areas, absent elsewhere; generally on level sites in gravelly or fine-textured andesite soils. SN, GB, Ro.

Oryzopsis hymenoides. Very rare; in a single site on the rocky ridge between South Sister and the plateau to the south; on andesite. SN, GB, Ro.

Phleum alpinum. Uncommon; in wet meadows; in organic soil. SN, GB, Ro, Ar.

Poa cusickii. Locally dominant; in flat to sloping meadows in fine-textured soils; usually on rhyolite. SN, GB, Ro.

Poa fendleriana. Uncommon; on rocky slopes in snow accumulation areas; most common on andesite. SN, GB, Ro.

Poa leibergii. Very rare; along the edges of wet meadows fed by persistent snowbanks; on rhyolite. SN.

Poa leptocoma. Very rare; in a wet meadow along upper Frying Pan Creek; in organic soil. SN, GB, Ro, Ar.

Poa nervosa. Rare; on steep, rocky slopes, probably under winter snow accumulation, in upper Ferris Canyon; on rhyolite. SN, GB, Ro.

Poa rupicola. Abundant and ubiquitous except in deep snow accumulation sites; most common on rhyolite, but present on other rock types. SN, GB, Ro.

Poa suksdorfii. Common; in many habitats, especially on scree and in shallow snow accumulation areas; more common on rhyolite, quartz monzonite, and granite than on andesite. SN.

Sitanion hystrix. Abundant and ubiquitous except in areas of deep snow accumulation; on all substrates except organic soil. SN, GB, Ro.

Stipa nevadensis. Rare; on rocky slopes at the head of Ferris Canyon; on rhyolite and andesite. SN, GB.

Stipa pinetorum. Rare; on a single, east-facing slope at the head of Ferris Canyon; on rhyolite. SN, GB, Ro.

Trisetum spicatum. Uncommon; in wet meadows and in some moist,

rocky snow accumulation areas; on various substrates. SN, GB, Ro, Ar.

Anthophyta—Dicotyledoneae

Apiaceae

Cymopterus cinerarius. Moderately common on andesite scree; rare on slopes in snow accumulation areas on rhyolite. SN.

Asteraceae

Achillea millefolium var. *alpicola*. Very rare; in moist scree at a rhyolite-andesite contact on Wheeler Peak; much more common slightly lower with *Artemisia nova*. SN, GB, Ro.

Agoseris glauca var. *monticola*. Uncommon; in snow accumulation areas on weathered andesite and dacite. SN, GB, Ro.

Antennaria alpina var. *media*. Moderately common; on rocky slopes of early-melting snow and in some wet meadows; on andesite, rhyolite and granite. SN, GB, Ro, Ar.

Antennaria corymbosa. Rare; moist meadows in organic soil. SN, GB, Ro.

Antennaria microphylla. Moderately common; on rocky areas that are probably under shallow winter snow; most common on rhyolite but present on other parent materials. SN, GB, Ro, Ar.

Antennaria umbrinella. Uncommon; gravelly to rocky soils in areas of shallow snow accumulation; on andesite. SN, GB, Ro, Ar.

Arnica longifolia. Very rare; on a single talus slope at the head of Ferris Canyon. SN, GB, Ro.

Artemisia ludoviciana subsp. *incompta*. Rare; on stable rocky rhyolite slopes near the lower edge of the alpine zone. SN, GB, Ro.

Aster alpigenus subsp. *andersonii*. Rare; in wet sedge meadows with organic soil. SN.

Chaenactis douglasii var. *rubricaulis*. Uncommon; on unstable scree and in disturbed sites on both rhyolite and andesite. SN.

Chrysothamnus parryi subsp. *monocephalus*. Moderately common; on rocky rhyolite slopes near the lower edge of the alpine zone; uncommon in similar sites at higher elevations. SN.

Chrysothamnus viscidiflorus subsp. *viscidiflorus*. Moderately common; on rocky rhyolite slopes near the lower edge of the alpine zone; uncommon in similar sites at higher elevations. SN, GB, Ro.

Crepis nana. Locally common; on andesite scree. SN, GB, Ro, Ar.

Dugaldia hoopesii. Uncommon; mostly in wet or moist meadows in organic soil; also rare on rocky andesite slopes. SN, GB, Ro.

Erigeron clokeyi. Rare; on rocky rhyolite or andesite slopes, usually on south-facing slopes near the lower edge of the alpine zone. SN.

Erigeron compositus var. *glabratus*. Uncommon; on rocky ridges on both rhyolite and andesite. SN, GB, Ro, Ar.

Erigeron petiolaris. Moderately common; on mesic scree in areas of shallow snow accumulation; mostly on rhyolite. SN.

Erigeron pygmaeus. Moderately common; on mineral soil in moist snow accumulation areas; on all rock types but more common on rhyolite. SN.

Eriophyllum lanatum var. *integrifolium*. Uncommon; in snow accumulation sites on rhyolite, granite, and altered andesite slopes. SN, GB.

Haplopappus apargioides. Locally common; on andesite scree or gravel surfaces. SN, GB.

Haplopappus macronema. Uncommon; generally on steep slopes or cliff ledges near the lower edge of the alpine zone; more abundant on andesite than on rhyolite. SN, GB, Ro.

Haplopappus suffruticosus. Rare; known from two sites on rocky rhyolite near the lower edge of the alpine zone. SN, GB.

Hulsea algida. Locally common in snow accumulation areas on deeply weathered andesite slopes; rare on rhyolite. SN, GB.

Hymenoxys cooperi var. *canescens*. Moderately common; on andesite and dacite slopes. GB.

Raillardella argentea. Uncommon; in snow accumulation areas, most commonly on east- or north-facing slopes; on gravelly rhyolite or rarely andesite. SN.

Senecio canus. Very rare; in a single snow accumulation area on stable andesite scree on the ridge connecting South Sister and the southern portion of the range. SN, GB, Ro.

Senecio integerrimus var. *exaltatus*. Rare; in flat, protected sites near the lower edge of the alpine zone; on andesite. SN, GB, Ro.

Senecio pattersonianus. Locally common; probably under at least shallow winter snow on rhyolite scree and quartz monzonite. Sweetwater and Wassuk Ranges.

Senecio werneriifolius. Locally common on gravelly slopes, most generally on east-facing slopes, in areas of shallow snow accumulation; mostly on andesite. SN, GB, Ro.

Solidago multiradiata. Very rare; known from only two sites in flat meadows. SN, GB, Ro, Ar.

Taraxacum officinale. Rare; in disturbed snow accumulation areas; mostly on andesite. SN, GB, Ro, Ar.

Townsendia condensata. Rare; in disturbed snow accumulation areas; mostly on andesite. White and Sweetwater Ranges.

Boraginaceae

Cryptantha glomeriflora. Rare; in most gravels. SN.

Cryptantha humilis. Uncommon; on rhyolite scree slopes, usually on exposed sites. SN, GB.

Cryptantha nubigena. Uncommon; on andesite slopes. SN.
Cryptantha watsonii. Rare; on a single disturbed gravel slope at the head of Ferris Canyon. SN, GB, Ro.

Brassicaceae

Anelsonia eurycarpa. Uncommon, but consistently present on loose andesite scree; rare elsewhere. SN.
Arabis inyoensis. Very rare; known from a single site on the south ridge of South Sister; in a community of low shrubs on andesite near the lower edge of the alpine zone. SN.
Arabis lemmonii var. *depauperata*. Moderately common in early-melting snow accumulation areas; on all substrates, but most common on rocky slopes. SN, GB, Ro.
Arabis lyallii. Rare; in early-melting snow accumulation areas on moist to dry rocky soils. SN, GB.
Arabis microphylla. Uncommon; in shallow snow accumulation areas, including frost-sorted polygons; principally on rhyolite. GB.
Arabis platysperma. Very rare; known from a single talus slope at the head of Ferris Canyon. SN, GB.
Barbarea orthoceras. Rare; found in two wet meadows in organic soils. SN, GB, Ro, Ar.
Descurainia richardsonii subsp. *viscosa*. Moderately common in fine-textured soils in snow accumulation areas; generally on andesite. SN, GB, Ro.
Draba albertina. Very rare; in a single moist meadow in mineral soil; on andesite. SN, GB, Ro.
Draba breweri. Locally common among rhyolite rocks, especially along the edges of fine-textured soil in frost-sorted polygons. SN.
Draba crassifolia var. *nevadensis*. Uncommon; in deep snow accumulation areas in pockets of fine-textured soil. SN, GB.
Draba densifolia. Locally abundant in gravelly soil of fellfields or shallow snow accumulation areas on both rhyolite and andesite. SN, GB, Ar.
Draba lemmonii var. *incrassata*. Very common in deep snow accumulation areas of rhyolite scree. A few individuals have completely glabrous leaves. Endemic.
Draba sierrae. Locally abundant; with *D. densifolia*. SN, GB.
Erysimum perenne. Moderately common in many habitats, especially under shallow winter snow and in subshrub communities; on both rhyolite and andesite. SN, GB.
Lesquerella cordiformis. Very rare; on dry east-facing scree on andesite. GB.

Caryophyllaceae

Arenaria aculeata. Moderately common; on well-drained scree slopes and flats; not usually on andesite. SN, GB.

Cerastium earlei. Common; in moist scree or mineral soil in shallow snow accumulation areas; generally on rhyolite. SN, GB, Ro.

Minuartia nuttallii subsp. *gracilis*. Moderately common; on well-drained scree slopes; more common on andesite, but also on rhyolite substrates. SN, GB.

Minuartia rossii. Rare; among rhyolite rocks on Mt. Patterson. SN, Ro, Ar.

Minuartia rubella. Rare; in moist mineral soil in sorted polygons; on rhyolite. SN, Ro, Ar.

Sagina saginoides. Rare; in organic soil in wet meadows. SN, GB, Ro, Ar.

Silene sargentii. Uncommon; on moist gravel slopes in snow accumulation areas on all rock types. SN.

Stellaria crispa. Uncommon; in wet sedge meadows. SN, GB.

Fabaceae

Astragalus kentrophyta var. *danaus*. Moderately common; on andesite scree slopes and gravel flats. SN.

Astragalus platytropis. Uncommon; on andesite scree slopes. SN, GB.

Astragalus purshii var. *lectulus*. Moderately common on andesite scree; rare on exposed slopes on other substrates. SN.

Astragalus whitneyi. Locally abundant in flat areas or gentle slopes among low shrubs near the lower edge of the alpine zone; on andesite; rarely present elsewhere. SN, GB.

Lupinus breweri var. *bryoides*. Locally abundant, but restricted to stable granite and quartz monzonite slopes near the lower edge of the alpine zone. SN.

Lupinus caudatus. Rare; in communities of low shrubs on andesite near the lower edge of the alpine zone. SN, GB.

Lupinus meionanthus. Rare; near the lower edge of the alpine zone in areas of shallow snow accumulation on andesite. SN.

Lupinus sellulus var. *lobbii*. Locally very abundant in many areas on flats and gentle slopes; mostly in fine-textured and disturbed soils of both rhyolite and andesite origin. In many places, there are large numbers of dead individuals heaved out of the soil, apparently by frost action. SN, GB.

Oxytropis parryi. Uncommon; restricted to andesite scree. SN, GB, Ro.

Trifolium longipes. Rare; in wet sedge meadows. SN, GB, Ro.

Trifolium monanthum. Rare; in sedge meadows and wet gravels along Frying Pan Creek. SN, GB.

Gentianaceae

Gentiana tiogana. Locally common in wet sedge meadows along the Frying Pan Creek drainage; in organic soil. SN.

Hydrophyllaceae

Phacelia frigida. Locally common on weathered andesite soils in areas of shallow snow accumulation or more exposed sites. SN.

Lamiaceae

Monardella odoratissima subsp. *parvifolia*. Rare; at a single location at the head of Ferris Canyon on rocky soil protected by shrubs. SN, GB, Ro.

Linaceae

Linum lewisii. Moderately common; on andesite scree and flats, especially near the lower edge of the alpine zone. SN, GB, Ro, Ar.

Onagraceae

Epilobium anagallidifolium. Uncommon; in wet areas along persistent streams or seeps. SN, GB, Ro, Ar.

Gayophytum racemosum. Moderately common; in open sites on gravelly soil in rhyolite and andesite. SN, GB, Ro.

Polemoniaceae

Ipomopsis congesta subsp. *montana*. Moderately common on andesite scree and less common on unstable rhyolite slopes. SN, GB.

Leptodactylon pungens subsp. *hallii*. Moderately common in communities of low shrubs on dry, rocky slopes. Some individuals approach *L. pungens* subsp. *pulchriflora*. GB; SN for *L. p. pulchriflora*.

Phlox caespitosa subsp. *pulvinata*. Abundant; in nearly all habitats except deep snow accumulation areas and steep barren scree. SN, GB, Ro.

Polemonium chartaceum. Rare; restricted to rocky rhyolite on South Sister and Mt. Patterson. White and Sweetwater Ranges.

Polemonium pulcherrimum. Uncommon; along the upper edges of snow accumulation areas; more common on andesite and dacite than on rhyolite. SN, GB, Ar.

Polygonaceae

Eriogonum anemophilum. Moderately abundant in highly weathered andesite soils, especially on exposed ridges and fellfields; uncommon to absent elsewhere. SN, GB.

Eriogonum lobbii. Locally abundant but known only from a single gentle gravel slope in a snow accumulation area along upper Frying Pan Creek. SN, GB.

Eriogonum ovalifolium var. *nivale*. Locally abundant; in fellfields on rhyolite and quartz monzonite; uncommon on rocky andesite slopes and in snow accumulation areas. SN, GB, Ro.

Eriogonum umbellatum var. *umbellatum*. Very rare; found in a single site on the northwest slope of South Sister near timberline; on rhyolite talus. SN, GB, Ro.

Oxyria digyna. Locally abundant; on wet, rocky north-facing slopes; generally on rhyolite. SN, GB, Ro, Ar.

Polygonum douglasii. Rare; in wet gravels. SN, GB, Ro.

Polygonum kelloggii. Rare; on moist soils of a few snow accumulation areas on both rhyolite and andesite. SN, GB, Ro.

Rumex californicus. Rare; in meadows that remain cold and wet throughout the summer. SN.

Rumex paucifolius subsp. *gracilescens*. Uncommon; in fine-textured soils in areas of shallow winter snow accumulation; generally on dacite. SN.

Portulacaceae

Calyptridium umbellatum. Locally abundant in fine-textured mineral soils of snow accumulation areas; found on various substrates, but most common in weathered andesite worked by pocket gophers. SN, GB.

Claytonia nevadensis. Uncommon; in moist rhyolite scree on Mt. Patterson; very rare elsewhere. SN.

Claytonia umbellata. Uncommon; in wet rhyolite scree. SN, GB.

Lewisia pygmaea. Locally common at the upper edge of some snow accumulation areas and in wet and moist meadows. SN, GB, Ro.

Montia chamissoi. Locally abundant in wet areas around springs along Frying Pan Creek and its tributaries; in organic soil on rhyolite. SN, GB, Ro.

Primulaceae

Androsace septentrionalis var. *subumbellata*. Moderately common in snow accumulation areas and moist or wet meadows; more common on rhyolite than andesite. SN, GB, Ro.

Dodecatheon alpinum. Rare; in wet sedge meadows. SN, GB.

Ranunculaceae

Ranunculus eschscholtzii var. *oxynotus*. Locally abundant in deep snow accumulation areas; most common on rhyolite scree. SN.

Rosaceae

Geum canescens. Rare; known from a single location in a moist meadow at the lower edge of the alpine zone along Frying Pan Creek. SN.

Holodiscus dumosus var. *glabrescens*. Very rare; a single individual found on an east-facing rhyolite cliff on Mt. Patterson. SN, GB, Ro.

Ivesia gordonii. Moderately common; in shallow snow accumulation

areas in fine-textured soils; generally on andesite, less common on rhyolite. SN, GB, Ro.

Ivesia lycopodioides. Uncommon; on rocky, moist soils in snow accumulation areas; most common on north-facing slopes. SN.

Potentilla breweri. Locally abundant on slopes of quartz monzonite; absent elsewhere. SN, GB.

Potentilla drummondii. Rare; in deep turf of wet meadows. SN, GB.

Potentilla pensylvanica var. *strigosa*. Uncommon; on dry, stable rhyolite slopes and fellfields and in frost-sorted polygons. SN, GB, Ro, Ar.

Potentilla pseudosericea. Rare; in fine-textured mineral soil at the center of sorted polygons near Wheeler Peak; on rhyolite. SN, GB, Ro.

Sibbaldia procumbens. Locally common in areas that remain cold and moist throughout the summer; on all substrates. SN, GB, Ro, Ar.

Rubiaceae

Galium hypotrichium subsp. *hypotrichium*. Rare; on east-facing andesite scree. SN.

Salicaceae

Salix orestera. Very rare; in wet sedge meadows along streams fed by persistent snowbanks. SN, GB.

Saxifragaceae

Heuchera duranii. Uncommon; on rocky slopes of quartz monzonite and granite; generally in drier areas of early-melting snow accumulation. White, Sweetwater, Wassuk Ranges.

Ribes cereum. Moderately common; principally on stable rocky slopes of andesite or rhyolite; not present in the most exposed sites. SN, GB, Ro.

Ribes inebrians. Rare; on rocky andesite slopes. SN, GB, Ro.

Ribes montigenum. Very rare; known from a single snow accumulation area at the lower edge of the alpine zone along the south ridge of South Sister. On andesite. SN, GB, Ro.

Scrophulariaceae

Castilleja nana. Moderately common in snow accumulation areas; generally on andesite, but also on dacite and rhyolite. SN, GB.

Limosella aquatica. Rare; in a single pool of standing water in a boggy meadow in upper Frying Pan Creek. SN, GB, Ro, Ar.

Mimulus coccineus. Locally abundant in disturbed gravels; on all substrates. SN, GB.

Mimulus primuloides. Rare; in wet sedge meadows near the lower edge of the alpine zone. SN, GB.

Mimulus suksdorfii. Rare; in moist unstable gravels of deep snow accumulation areas. SN, GB, Ro.

Mimulus tilingii. Rare; on the edge of a single wet sedge meadow on the south slope of Wheeler Peak. SN, GB, Ro.

Pedicularis attollens. Rare; in wet sedge meadows. SN.

Penstemon davidsonii. Very rare; found only on an east-facing rhyolite cliff south of Mt. Patterson. SN, GB.

Penstemon heterodoxus. Rare; in fairly flat, moist, gravelly soil near the lower edge of the alpine zone; on both andesite and rhyolite. SN.

Penstemon procerus. Rare; in flat, moist gravels along Frying Pan Creek. SN, GB, Ro.

Penstemon speciosus. Very rare; at the lower edge of the alpine zone in andesite soils; much more common in nearby *Artemisia nova* communities. SN, GB.

Veronica wormskjoldii. Very rare; in wet organic soils along Frying Pan Creek. SN, GB, Ro, Ar.

Valerianaceae

Valeriana californica. Rare; in a single snow accumulation area on andesite scree on the south ridge of South Sister. SN, GB.

Discussion

The alpine flora of the Sweetwater Range with 173 species of vascular plants is unusually diverse. Among Great Basin ranges, larger alpine floras have been described only in the Ruby Mountains with 189 species (Billings 1978) and the White Mountains with about 200 species (Lloyd and Mitchell 1973).

The 173 species in the alpine zone of the Sweetwaters are found in an area of only 16.0 km^2. Plant species-area curves for Great Basin montane zones predict only about 120 species in such an area (Harper et al. 1978), although the same curve accurately predicted the size of the alpine flora of the Wassuk Range, 48 km to the east of the Sweetwaters (Bell and Johnson 1980). The species-area curves of Harper et al. (1978), however, suggest that the Sweetwater flora is more like that of an island than that of a mainland. The latter would have about 300 species in a comparable area.

The richness of the Sweetwater alpine flora must result in part from the unusual diversity of habitats available in the small alpine area. These habitats range from flat meadows to cliffs, from xeric talus and scree slopes to wet meadows and ponds, from stable meadows and slopes to actively frost-mobile soils and loose scree. The geology of the range also appears to exert a highly significant influence on plant distributions within the range. The two predominant rock types, rhyolite and andesite, offer very different chemical and thermal re-

Table 1. Geographic Distribution of Alpine Plants in Four Mountain Ranges Along the Western Perimeter of the Great Basin. Distributions of SN (Sierra Nevada), BG (Great Basin), Ro (southern Rocky Mountain) and Ar (Arctic) species are based upon references cited in the text.

	Contribution to flora							
	Sweetwater		Wassuk		White		Spring	
Distribution	Number of taxa	Percent of flora	Number of taxa	Percent of flora	Number of taxa	Percent of flora	Number of taxa	Percent of flora
SN	34	19.7	5	7.1	31	17.8	1	2.4
SN, GB	38	22.0	16	22.9	27	15.5	3	7.3
SN, GB, Ro	58	33.5	28	40.0	55	31.6	8	19.5
SN, GB, Ro, Ar	27	15.6	13	18.6	28	16.1	6	14.6
GB	4	2.3	4	5.7	4	2.3	3	7.3
GB, Ro	1	0.6	1	1.4	5	2.9	2	4.9
GB, Ro, Ar	0	—	0	—	1	0.6	0	—
SN, GB, Ar	2	1.2	1	1.4	0	—	0	—
SN, Ro, Ar	3	1.7	0	—	2	1.1	1	2.4
SN, Ro	1	0.6	0	—	4	2.3	0	—
Spring, White, Sweetwater, Wassuk only	4	2.3	2	2.9	5	2.9	1	2.4
Ro	0	—	0	—	2	1.1	0	—
Ro, Ar	0	—	0	—	1	0.6	0	—
Endemic	1	0.6	0	—	3	1.7	9	22.0
Southern Utah	0	—	0	—	0	—	2	4.9
Other	0	—	0	—	4	2.3	5	12.2

gimes, and many species are clearly confined to a single rock type. Contacts between substrates generally delimit abrupt transitions between plant associations. Restriction of local plant distributions by rock type has been reported only rarely for alpine areas, and the clear examples of such limitation seen in the Sweetwaters make the range attractive for future studies of the role of edaphic factors in determining local plant distribution.

The position of the Sweetwater Mountains along the transition between the Great Basin and Sierra Nevada floras also appears to contribute to the large number of species present. To assess the significance of this location, it is helpful to compare the alpine flora of the Sweetwaters with those of the Wassuk, White and Spring Mountains. Analysis of the Wassuk flora can be derived from Bell and Johnson (1980). An alpine species list for the White Mountains was developed from Lloyd and Mitchell's (1973) flora, including all taxa listed above 3200 m and those found in wet meadows or rocky slopes devoid of trees between 3000 and 3200 m. This method identified 174 alpine taxa compared with approximately 125 strictly alpine and 75 facul-

TABLE 2. PERCENT OF FLORA IN WESTERN GREAT BASIN RANGES FOUND IN OTHER REGIONS.

Region	Percent of flora			
	Sweetwater	Wassuk	White	Spring
Sierra Nevada	94.2	90.0	85.1	46.3
Great Basin	75.1	90.0	69.0	53.7
Southern Rocky Mountains	52.0	60.0	56.3	41.5
Arctic	18.5	20.0	19.0	17.1
Endemic	0.6	0.0	1.8	22.0

tative alpine taxa cited by Lloyd and Mitchell (1973). For Mt. Charleston in the Spring Mountains a list of 41 species likely to be found in the alpine zone was derived from Clokey (1951) by including all taxa occurring above 3300 m and all timberline species. These White and Spring Mountain alpine floras were analyzed by the same methods applied to the Wassuk and Sweetwater floras.

Results of this comparison (Tables 1, 2) show that, of all the ranges along the western edge of the Great Basin, the Sweetwaters have the highest proportion of their taxa in common with the Sierra Nevada and the second highest proportion in common with the Great Basin. Thus, the proximity to both floristic provinces appears significant for the presence of an unusually diverse alpine flora.

The low degree of isolation of the Sweetwater and Wassuk ranges is also clear from the virtual absence of endemics in their alpine floras. The lower and hotter valleys between ranges to the south serve to isolate the White and especially the Spring Mountains, thereby allowing evolution of endemic taxa (Clokey 1951, Billings 1978).

The largest floristic element in all four ranges is made up of species that are widespread in western North America. This pool of widespread species (including many members of the Cyperaceae, Poaceae, and Rosaceae) appears to exhibit unusual mobility, although no common feature of seed morphology suggests an obvious mode of migration. Billings (1978) notes that Sierran plants appear to be generally poor at migrating eastward. A modest number of Great Basin taxa also appear unable to invade the Sierra Nevada from the Sweetwater or White Mountains. Taylor (1976b) reports a number of Great Basin taxa occurring in the vicinity of Carson Pass in the northern Sierra Nevada, but other species (e.g., *Elymus cinereus, Arabis microphylla, Lesquerella cordiformis*) appear to reach their western limits in the Sweetwater Mountains. These species have dispersed across the broad, low-lying valleys separating the Wassuk-Sweetwater complex from Great Basin ranges to the east. The high pass between the Sweetwaters and Sierra Nevada should be a trivial barrier by comparison. The failure of these plants to migrate further west supports Taylor's (1976b)

hypothesis that competition from mesophytes in the Sierra Nevada is intolerable to some plants adapted to the more xeric conditions of the rain shadow. Although dispersal mechanisms remain unknown, the presence of very widespread taxa may reflect broad ecological tolerances rather than just some particularly effective mode of migration.

Acknowledgments

We are grateful to G. F. Brem (Geology Department, California State University, Fullerton) for making available his unpublished information on surface geology of the Sweetwater Range. We thank the following for assistance with plant identification: W. E. Niles, D. B. Dunn (*Lupinus*), G. K. Brown (*Haplopappus*), and L. C. Anderson (*Chrysothamnus*). The curators of UNLV, WS, and RSA provided access to collections. Supported in part by grants from the University Research Council of the University of Nevada, Las Vegas, and by travel funds from the Charles R. Conner Museum, Washington State University.

Literature Cited

Bell, K. L. and R. E. Johnson. 1980. Alpine flora of the Wassuk Range, Mineral County, Nevada. Madroño 27:25–35.

Billings, W. D. 1978. Alpine phytogeography across the Great Basin. Great Basin Naturalist Mem. 2:105–117.

Clokey, I. W. 1951. Flora of the Charleston Mountains, Clark County, Nevada. Univ. Calif. Publ. Bot. 24.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal. 1972. Intermountain flora: vascular plants of the Intermountain West, U.S.A. Vol. 1. Hafner Publ. Co., NY.

———, ———, ———, ———. and P. K. Holmgren. 1977. Intermountain flora: vascular plants of the Intermountain West, U.S.A. Vol. 6. Columbia Univ. Press, NY.

Hansen, C. G. 1956. An ecological survey of the vertebrate animals on Steen's Mountain, Harney County, Oregon. Ph.D. dissertation, Oregon State College, Corvallis.

Harper, K. T., D. C. Freeman, W. K. Ostler, and L. G. Klikoff. 1978. The flora of Great Basin mountain ranges: diversity, sources, and dispersal ecology. Great Basin Naturalist Mem. 2:81–103.

Harrington, H. D. 1964. Manual of the plants of Colorado. 2nd ed. Sage Books, Chicago.

Kartesz, J. T. and R. Kartesz. 1980. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Vol. II. The biota of North America. Univ. North Carolina Press, Chapel Hill.

Lewis, M. E. 1971. Flora and major plant communities of the Ruby-East Humboldt Mountains with special emphasis on Lamoille Canyon. Humboldt Natl. Forest, U.S. Forest Service, Region 4.

———. 1973. Wheeler Peak area species list. U.S. Forest Service, Ogden, Utah.

———. 1975. Plant communities of the Jarbidge Mountain complex, Humboldt National Forest. U.S. Forest Service, Ogden, Utah.

Linsdale, M. A., J. T. Howell, and J. M. Linsdale. 1952. Plants of the Toiyabe Mountains area, Nevada. Wasmann J. Biol. 10:129–200.

Lloyd, R. M. and R. S. Mitchell. 1973. A flora of the White Mountains, California and Nevada. Univ. Calif. Press, Berkeley.

Loope, L. L. 1969. Subalpine and alpine vegetation of northeastern Nevada. Ph.D. dissertation, Duke Univ., Durham, NC.

MAJOR, J. and D. W. TAYLOR. 1977. Alpine. *In* M. G. Barbour and J. Major, eds., Terrestrial vegetation of California, p. 602–675. Wiley-Interscience, NY.

MCMILLAN, C. 1948. A taxonomic and ecological study of the flora of the Deep Creek Mountains of central western Utah. M.S. thesis, Univ. Utah, Salt Lake City.

MUNZ, P. A. 1973. A California flora with supplement. Univ. Calif. Press, Berkeley.

POLUNIN, N. 1959. Circumpolar arctic flora. Clarendon Press, Oxford.

PREECE, S. J., JR. 1950. Floristic and ecological features of the Raft River Mountains of northwestern Utah. M.S. thesis, Univ. Utah, Salt Lake City.

SHARSMITH, C. W. 1940. A contribution to the history of the alpine flora of the Sierra Nevada. Ph.D. dissertation, Univ. Calif., Berkeley.

SLEMMONS, D. B. 1966. Cenozoic volcanism of the central Sierra Nevada, California. *In* Geology of northern California. Calif. Div. of Mines and Geology Bull. 190: 199–208.

TAYLOR, D. W. 1976a. Ecology of the timberline vegetation at Carson Pass, Alpine County, California. Ph.D. dissertation, Univ. Calif., Davis.

———. 1976b. Disjunction of Great Basin plants in the northern Sierra Nevada. Madroño 23:301–310.

WEBER, W. A. 1976. Rocky Mountain flora. Colorado Associated Univ. Press, Boulder.